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respect is to spray the growing crop with the solution of a chemical which kills the weeds and does not injure the crop. The chemical employed for this purpose is ferrous sulphate in a ten-per-cent. solution. It does not injure cereals, corn or even grasses and clover, but destroys or retards the growth of the most noxious weeds to such an extent that the yield of crops has been increased twenty per cent.

One of the greatest services which chemistry has rendered to the amelioration of the farmer's vocation is the protection assured against artificial and fraudulent imitations of numerous genuine products. A few of the most vicious abuses, through which the farmer and consumer suffered alike, were the sale of oleomargarine for genuine butter, which almost destroyed the dairy industry; the sale of artificially colored distilled vinegar for cider vinegar, which caused millions of bushels of apples to rot in the orchards of the country; the sale of glucose for maple syrup and honey; the sale of skim milk for whole milk; and the sale of skim-milk cheese for full cream cheese.

It is gratifying to refer to the aid which the governments of all civilized nations have given in recent times for the purpose of elevating and perpetuating the art of agriculture, the industry most important to the welfare of humanity. Agricultural colleges and experiment stations, agricultural departments, both national and state, have been established and richly endowed. These are filled with earnest and honest investigators, who are working diligently and faithfully to disseminate truths, already established, among the rural population and to discover new ones, by which this noble vocation may be advanced. May the good work go on.

H. A. WEBBER

RELATION OF CHEMISTRY TO THE INDUSTRIES

I AM gratified that an opportunity has been given me to be present on this occasion and take part in the installation of the new head of the department of chemistry of this great university. To me it is a matter of no little significance, and to all of us, interested, as we are, in the promotion of the work of the institution and its material and scientific progress, it is almost the beginning of a new era in its development. We may congratulate ourselves that the officers charged with the duty of seeking out and appointing the new incumbent, should have had such good fortune in their search, and should have chosen so well. But I know you will sympathize with me when I say that the pleasure and gratification which comes to us now must be tempered by the remembrance of the real cause which brings us together: the early and untimely removal of the late head of the department. To me it brought keen sorrow. I knew Dr. Palmer as a youth, just emerging into manhood. Earnest, enthusiastic, industrious and skilful, he came to his work with qualities of mind calculated to make him a leader among his fellows, and to cause him to quickly take a high position in his chosen profession. A persistent reader of the literature even in his student days, a deep and accurate thinker, a rapid manipulator, confident of the accuracy of his results, he was able to accomplish more within a given time than most men; and all this, combined with a vivid and useful imagination, made possible for him splendid progress in research and opened for him a career which must certainly have placed him in the forefront of the profession, and made him a leading chemist in his country and in the world.

As a teacher the same qualities made him successful. Students respect and follow

successful men—men who work earnestly and produce useful results. Such results were manifest as an outcome of all the efforts Dr. Palmer put forth. While we mourn him personally as a friend and colleague, we realize the loss to the world of chemistry and the industries, caused by his death. But in this case particularly we must realize that the oft repeated adage, "The evil that men do lives after them," must be modified, and we may say, "The good he has done lives after him," in the men he has trained, in the results of his investigations, in the publications of his work now within our reach, in his influence upon the standing and position of the university generally. We may congratulate the university and its corps of administration and instruction that so many of her sons should have been so influential and instrumental in establishing the splendid position she occupies in the eyes of her graduates and the world at large.

I have been invited at this time to discuss the relations of chemistry to the industries, and in this, to me, most interesting duty, to occupy fifteen minutes. It is fair to remind you and the committee having these exercises in charge that this has, more than once, been the subject of an encyclopedia of many volumes, that it constituted one of the most important departments of our late national census, reported in several hundred quarto pages. To adequately discuss the subject, therefore, I should be forced to trespass upon your good nature and the wishes of the committee; the day would be all too short, and your patience and strength, as well as my own, would be sorely taxed. You may not expect me, therefore, to offer more than a syllabus of what might be said in the several hours or the several addresses which should be allotted to the subject.

The head of the department will, I hope,

have many years to exploit it, for to be fully successful he may not avoid these relations omnipresent. The utilitarianism of our age makes it important that theory and practise, science and industry, shall go hand in hand to insure progress on either side. The good flowing from the relation in question is reciprocal. If the science of chemistry has furnished the industry with knowledge and facts and suggestions, the practise of chemistry in the industry by its needs, by its difficulties, by its successes, has furnished to the science suggestions, facts and knowledge which have been helpful, stimulating and inspiring. The best that can be said of the relations of chemistry to the industries is, the closer they are the better for both. The necessity arising from the large production of wastes in the manufacture of illuminating gas, the utilization of coal tar, which had become an intolerable nuisance, led simultaneously to the establishment of the great color industries, with consequent stimulation of all the allied industries, to the development of the chemistry of the carbon compounds in general, and furnished materials through the study of which the laws of modern chemistry could be worked out and confirmed. It is well known that many of these materials could be produced only when operating in a large way in manufacturing establishments and by methods available only in the industries. It is in this way, as well as others, that the industries have been helpful in the development of the science. But reciprocally the science and its methods, abstract research in the laboratories, have been helpful, nay, necessary to the industries. This is splendidly illustrated in the memorable address of Professor Crookes before the chemical section of the British Association for the Advancement of Science, in the meeting in Bristol, in which, sounding the note of

alarm regarding the possible deficiency of the bread supply of Great Britain, due to shortage of nitrogenous plant food in the wheat fields, and advocating the proposed parliamentary legislation for the establishment of national granaries in which supplies of wheat could be stored for protection against national famine, he described methods and apparatus used by himself in abstract research and later by Lord Rayleigh in the search for argon, methods and apparatus whereby atmospheric nitrogen and oxygen could be made to combine with each other with expenditures of energy so low as to make the utilization of atmospheric nitrogen a commercial possibility at costs as low as or lower than the element could be supplied in combination in niter from the celebrated deposits of Chili, until then the sole source of economic supply after the exhaustion of the guano deposits of the world.

The combination of nitrogen and oxygen of the atmosphere through the intervention of the electric arc and the silent electric discharge or under the influence of electrical tension has become commercially an accomplished fact, and other means for fixation of atmospheric nitrogen in forms available for plant food have been worked out, notably the process of Caro and Frank, whereby nitrogen is made to combine with calcium carbide to form calcium cyanamide, since proved to be as efficient for plant food as calcium nitrate or ammonium sulphate. The research laboratory was the direct means for producing these brilliant and immediately useful results. So also the biological studies of Berthelot, which led to the discovery of the nitrogen-fixing bacteria of clay soils; of Wilfarth and Hellriegel, which led to the discovery of nitrogen-fixing bacteria of the root nodules of leguminous plants, notably of clover; of Muntz, which led to the discovery of the

nitrifying bacteria of soils, through the agency of which the nitrogen of organic matters and ammonia is changed to the nitric combinations, in which alone it is available for the uses of vegetation. All these have done their share to reduce and remove the threatened danger which Professor Crookes justly saw and which has now been unquestionably removed by the discoveries, then far from commercial attainment, he at the same time described. Abstract research is still essential to progress in the industry, even as it was in his day recognized to be by the great Napoleon, who, realizing that political supremacy is largely, if not wholly, dependent upon industrial supremacy, called to his aid, after the establishment of the celebrated continental blockade, all the great minds of the institute and the academy, to devise and develop means whereby the needs of his empire could be wholly met by internal resources, and out of this grew many of the great industries of France and the world generally: the beet-sugar industry, the madder crop, the production of indigo, the development of the textile industries, particularly in linen and wool. This necessity of industrial supremacy to the assurance of the political supremacy has been recognized by other great statesmen and leaders. What Napoleon saw, the great German Kaiser of the present day saw when he urged and insisted upon the establishment of the engineering doctorate of the universities of his empire, and Senator Morrill saw when he urged upon the Congress of the United States the enactment of the great land-grant law for the establishment of the colleges of agriculture and the mechanic arts, from which this and other great universities of the land have grown. This is, furthermore, what Congressman Hatch saw when he proposed to and urged upon the congress the enactment

of the law providing for the establishment and support of the agricultural experiment stations to be devoted to scientific research and the more intimate study of the problems of agriculture pressing for solution; and it is what van Rensselaer, Cornell, Packer, Pardee, Johns Hopkins, Harrison and Rockefeller saw and felt when they made generous provisions for the great universities and schools of technology for training young men in the sciences in their relations to the industries and the arts of human life. It is such genius and its applications which insures the world's progress.

Genius has been defined as "capacity for hard work." It is far more. It is a keen and active imagination combined with industry, energy and ambition to bring to fruitful realization the product of a trained imagination. This leads us to some of the needs of modern education in its relations to our subject. Genius as thus defined and described must be developed in the student of this age. The imagination must be trained and directed, the judgment strengthened. Thus genius becomes a keen and trained imagination, combined with good judgment and an industrious habit, with energy to bring to fruition the work of the imagination. So we should educate our students to the importance of a clear and exact knowledge of the work of others as recorded in literature, for progress means building upon the work of others. They should then be trained in the judicious and scientific use of the imagination suggested by the great Tyndall, whereby they may be able to see how the accomplishments of others may be extended and utilized. Then the power of observation must be developed, and hence the need for and usefulness of the research laboratory, happily recognized more and more as the years pass, in the systems of education and

in the organizations of the great industries. It is interesting and inspiring to one concerned with educational matters to see how far the research laboratory is being attached to and made part of the manufacturing plants of this and other countries. It has been claimed that the research laboratories have been the foundation stones upon which the great structure of the German chemical industry has been reared, and the claim can not be questioned. It was inspiring, upon a visit to one of the great chemical works of Germany, where more than 3,000 hands were employed, to see an entire, large, well-arranged, well lighted and ventilated building devoted wholly to abstract research in lines related to the industry, occupied by hundreds of chemists engaged in the work for which the building was provided. And it was even more interesting to follow the results of the research carried on in the several laboratories of that great building.

In this connection we may call attention to the brilliant work lately reported by Professor Harries, of the Technical High School of Charlottenburg, Germany, in the study of the constitution of caoutchouc, or india rubber. By oxidation of the pure gum with ozone he was able to produce what he named its diozonide, and this by proper treatment was converted into levulinic aldehyde, which in turn was oxidized to levulinic acid. This, Professor Harries reminds us, can be obtained more readily and cheaply from starch than from any other material, and he suggests that by a series of deoxidations and condensations, starch may be converted into caoutchouc, which has become so useful and almost indispensable in the industries and yet is provided in such comparatively limited quantity in nature that there is almost a dearth of it in the world's market to-day. It would be interesting, indeed, if we

should come to depend for our india rubber supply upon the cornfields of Illinois, the prairies of the Mississippi basin and the manufacturing laboratories, rather than, as in the past and now, upon the jungles of Africa and South America. Yet the production of india rubber from corn starch would be no more remarkable than the production of alizarine and indigo from coal tar. The research laboratory is the source from which artificial alizarine and artificial indigo sprang; the same source may be the starting point of the production of india rubber from indian corn.

What may we expect from the recent announcement of Professor Ramsay that under the influence of the radium emanation copper may be broken down with the production of potassium, lithium and calcium, thus suggesting a new source for potassium compounds, so useful to farm crops?

Other products and questions await the magic touch of the research chemist. Who for instance, will take care of and utilize the comparatively large quantities of selenium and tellurium, thus far so little studied and now so largely issuing as a by-product of the manufacture of vitriol and the refining of copper? Here is abundant supply of raw material to be had from the industry by the research chemist for the asking. Again, who will supply the volatile combustible required to make up the shortage of supplies of petroleum products needed for use in the internal combustion engines, upon which the future must largely depend for inexpensive power? Who will furnish other products sorely needed in the world if not the research chemist? In this connection I am again constrained to quote the inspiring words written by the editor of the *Wall Street Journal* under the caption "Science as a Financial Asset." Among other things this accomplished editor said:

Science as a source of strength in promoting private wealth and public welfare is the one thing that draws the line of demarcation between ancient and modern times. That was a belated mediæval, not a modern, outburst of popular wrath against which Lavoisier's friends appealed for his life on the ground of his scientific service to the French state. The powers then in control then replied that the republic had no use for chemists. Far more like modernity is the declaration of a German chemist that "scientific research is the greatest financial asset of the fatherland." Germany's economic progress proves that he was at least nearer right. The sciences in general have been among the greatest emancipating forces, because they have helped to overcome man's fear of nature, which kept him from utilizing the forces of the world about him, and because they disclosed elements of the highest value to the world in their most practical forms. It has been well said that if we were to take away what the chemists have contributed, the whole structure of modern society would break down at once. Every commercial transaction in the civilized world is based on the chemist's certificate as to the fineness of gold, which forms our ultimate measure of values. Faith may remove mountains, but modern society relies on dynamite. Without explosives our great engineering works must cease and the Panama Canal, no less than modern warfare, become impossible! Chemistry has made possible the transportation systems which span the leading countries of the world. It has made it possible to turn to man's service the wealth of the mineral world. By analysis of plants and soils, the waste materials of the world have been brought to the growing of crops. Indeed, every great industry, whether it be farming, manufacturing, transportation or mining, would almost immediately relapse to barbarism if the secrets of the chemist and physicist, the geologist and mineralogist, could be gathered up and cast into the sea.

This estimate of the work of the research chemist has our hearty sympathy and it brings much of inspiration and encouragement. It justifies all that the rulers and legislators have done for this and similar institutions and loudly calls for generous support in the future. It expresses appreciation of the work done in this university, which has made such magnificent progress under the direction of its present very effi-

cient head and the splendid promise for its immediate future. All here present will, I am sure, heartily join me in wishing for the university and for its department of chemistry no diminution of the splendid prosperity which has attended the efforts of its excellent administration in the recent past.

WILLIAM MCMURTRIE

*CHEMICAL RESEARCH IN AMERICAN
UNIVERSITIES*

GATHERED here to-day to celebrate the installation of one of our prominent American investigators as director of chemistry in the University of Illinois, we should not do justice to the occasion if our thoughts did not turn to the serious meaning of this event for the future of chemical research in our universities. I have thought to devote the few minutes, during which I shall have the pleasure of addressing you, most usefully to the consideration of some conditions affecting the future of chemical research in our American universities.

Before this audience I need make no lengthy plea of justification for the demand for research work in chemistry in our universities, either on the ground of economic considerations or from the standpoint of our highest ideals, as expressed in the struggle of the human race for enlightenment on itself. As Professor Theodore W. Richards recently said in his inaugural lecture at the University of Berlin:

All the manifold experiences of the human mind are intimately connected with the presence of that which we call material, enlivened by that which we call energy; and the ultimate deciphering of the great mystery of life will depend just as much on the understanding of these as upon the study of the mind itself. Thus modern chemistry should be regarded not only as bringing to medicine and the useful arts its obvious and multifarious contributions, but as occupying also an essentially important place in the realm of intellectual speculation.

After Dr. McMurtrie's address it is unnecessary to say much about chemistry in the field of economics. It is a trite fact now that the industrial and commercial supremacy of Great Britain is threatened most dangerously by the wonderful growth of manufacturing in Germany. Englishmen, noting this in the face of the fact that they themselves are rather favored in the matter of natural resources and wealth, are attributing the great strength of their competitors almost entirely to their splendidly trained army of chemists. A significant fact is that this onward march of the German industries is characterized by much of the same fearlessness and supreme confidence of victory as was its march on the unprepared armies of France forty years ago; and for much the same reason—again, it is splendidly organized—organized in the matter of trained scientists, chiefly chemists; its industrial adversary is not—as yet. Chemistry, in some form or other, enters into the production and manufacture of almost all the great articles of commerce—from the raising of wheat and corn on soils scientifically analyzed and fertilized, to the making of steel and all iron materials, from the preparation of brilliant dyes to that of common leather, from the drugs of our sick days to the food products of our daily life—all can be developed best under the direction or with the help of able chemists, and, what is equally important, all, without exception, are capable of vast improvement under the seeing eyes of the chemist, trained to observe closely, to reason accurately, to think originally, to experiment rigorously—trained, in a word, to do research work. German universities and polytechnic schools are turning out such chemists, doctors of philosophy, by the hundred—men trained to investigation, so that they can improve and develop new ways for